

STUDY OF UNIDENTIFIED EGRET SOURCES WITH INTEGRAL: FIRST RESULTS AND FUTURE PROSPECTS

G. Di Cocco¹, A.J. Castro-Tirado², S. Chaty^{3,4}, A.J. Dean⁵, M. Del Santo⁶, L. Foschini¹, N. Gehrels⁷, P. Grandi¹, I. Grenier^{3,4}, W. Hermsen⁸, L. Kuiper⁸, N. Lund⁹, G. Malaguti¹, F. Mirabel³, and R. Much¹⁰

¹IASF/CNR, Sezione di Bologna, via P. Gobetti 101, 40129 Bologna, Italy

²Instituto de Astrofísica de Andalucía (IAA-CSIC), P.O. Box 03004, E-18080 Granada, Spain

³Service d'Astrophysique, Centre d'Études de Saclay, DSM/DAPNIA/SAp, CEA-Saclay, F-91191, Gif-sur-Yvette, Cedex, France

⁴Université Paris 7, Denis-Diderot 2, place Jussieu 75251 Paris Cedex 05, France

⁵Department of Physics and Astronomy, Southampton University, UK

⁶IASF/CNR, Sezione di Roma, via del Fosso del Cavaliere 100, Roma, Italy

⁷NASA Goddard Space Flight Center, Laboratory for High Energy Astrophysics, Code 661, Greenbelt, MD 20771, USA

⁸SRON National Institute for Space Research, Sorbonnelaan 2, 3584 CA Utrecht, The Netherlands

⁹Danish Space Research Institute, Juliane Maries Vej 30, 2100 Copenhagen, Denmark

¹⁰ESA/ESTEC, Keplerlaan 1, Postbus 299, 2200 AG Noordwijk, The Netherlands

ABSTRACT

The primary objective of the study of unidentified EGRET sources with INTEGRAL is to locate with a few arcminute accuracy the hard X-ray / soft γ -ray counterparts within the EGRET error circle or to determine upper limits on their emission in the INTEGRAL energy range. The INTEGRAL Galactic Plane Scan (GPS) and Galactic Centre Deep Exposure (GCDE) data have been analysed and cross-correlated with the EGRET 3rd Catalogue to search for counterparts of EGRET sources. The IBIS detection of a source within the EGRET error circle of 3EG J1736 – 2908 is presented and its possible identification with the active galaxy GRS 1734 – 292 is discussed. Finally, preliminary results on the cross-correlation between EGRET unidentified sources and the first data from the IBIS survey of the Galactic Centre are presented.

Key words: Gamma rays: observations – Galaxies: active – Galaxies: Individuals: GRS1734 – 292.

1. INTRODUCTION

The 3rd Energetic Gamma-Ray Experiment Telescope (EGRET) Catalogue of high-energy ($E > 100$ MeV) γ -ray sources (Hartman et al. 1999) refers to the observations carried out by the EGRET experiment on-board the Compton Gamma-Ray Observatory (CGRO) between April 1991 and October 1995. It contains 271 point sources, including: 1 solar flare, the Large Magellanic Cloud, 5 pulsars, the radio galaxy Centaurus A,

and 66 high-confidence identifications of blazars. In addition, 27 lower-confidence blazar identifications are included in the catalog, which leaves 170 sources unidentified. Since the publication of the catalog, a lot of effort has been dedicated to the identification of the 170 unidentified EGRET sources (Grenier 2003). While most of the extragalactic counterparts are blazars, two possible identifications of EGRET sources with radiogalaxies have been recently proposed (Combi et al. 2003, Mukherjee et al. 2003), in addition to the well known radiogalaxy Cen A. However, the multiwavelength counterpart search is hampered by the limited EGRET point spread function, which gives error radii of $0.5^\circ - 1^\circ$.

One of the two main telescopes on board INTEGRAL (Winkler et al. 2003) is the IBIS imager (Ubertini et al. 2003). IBIS combines for the first time broad band high energy coverage (15 keV – 10 MeV) with imaging capability. IBIS has a large field of view ($19^\circ \times 19^\circ$ at half response), and a fine angular resolution of $12'$, sampled in $5'$ pixels in the low energy (0.015 – 1 MeV) layer ISGRI (Lebrun et al. 2003), and in $10'$ pixels in the high energy (0.175 – 10 MeV) detector PICsIT (Di Cocco et al. 2003). ISGRI reaches a point source location accuracy better than $1'$ for a 30σ detection (Gros et al. 2003). These unprecedented characteristics for a γ -ray telescope clearly make IBIS one of the best instruments available to date to search for counterparts of unidentified EGRET sources. Within the framework of the Core Programme (CP) observations, a project has been set up to systematically search for associations between INTEGRAL sources and EGRET unidentified error sources. A first possible identification of an EGRET source has already been found (see Di Cocco et al. 2004, A&A submitted, for details).

2. THE CASE OF 3EG J1736 – 2908

Every single pointing (Science Window, ScW) of the INTEGRAL Core Programme observations is progressively analysed, and all the sources detected with signal-to-noise ratio (SNR) greater than 6σ are cross-correlated with the 3rd EGRET Catalogue to look for possible identifications. All the INTEGRAL data analysis described in the present work has been done with the latest version of the Offline Standard Analysis (OSA) available through the INTEGRAL Science Data Centre (ISDC¹) and whose algorithms are described in Goldwurm et al. (2003).

During these scans, one source within the probability contours of 3EG J1736 – 2908 was found with a statistical significance of $\approx 10\sigma$ in the ScW 57 of revolution 61 (Fig. 1, *top*). The source, later identified with the active galaxy GRS1734 – 292, had a flux of $(2.1 \pm 0.3) \times 10^{-10}$ erg cm⁻²s⁻¹ (or 28 ± 4 mCrab) in the 20 – 40 keV energy band.

The detection significance was increased with the mosaic obtained by adding together all the ScWs containing the 3G J1736 – 2908 region within 10° from the centre of the field of view (FOV). The obtained images (Fig. 1, *centre* and *bottom* panels) correspond to an effective exposure time of ~ 320 ks. The source position (90% confidence radius = $1.2'$) obtained with this longer exposure, $\alpha = 17 : 37 : 27$ and $\delta = -29 : 08 : 24$ (J2000), is fully compatible with the single ScW detection, while the detection significances increased to 17σ and 8.5σ , in the 20 – 40 and 40 – 60 keV, respectively. The corresponding fluxes are $(4.9 \pm 0.4) \times 10^{-11}$ erg cm⁻² s⁻¹ and $(2.1 \pm 0.3) \times 10^{-11}$ erg cm⁻² s⁻¹, respectively.

GRS1734 – 292 is also clearly visible in the mosaics of the Galactic Centre presented by Paizis et al. (2003), in the field of view of the black hole candidate H1743 – 322 observation by Parmar et al. (2003), and in the IBIS survey of the Galactic Centre region performed by Revnivtsev et al. (2004). The flux and the detections are consistent with the present results.

For more details about the possible identification of GRS1734 – 292 as counterpart of 3EG J1736 – 2908 we refer the reader to Di Cocco et al. (submitted to A&A).

3. SEARCH FOR OTHER COUNTERPARTS OF EGRET UNIDENTIFIED SOURCES

The 2 Ms IBIS/ISGRI mosaic by Revnivtsev et al. (2004) gives a list of sources detected in the central radian of the Milky Way down to a limiting flux of 1.3×10^{-11} erg cm⁻² s⁻¹. Therefore, we performed a cross-correlation of the 3rd EGRET Catalog with the source list of Revnivtsev et al. (2004). The results shown in Fig. 2 confirm that GRS1734 – 292 is the only source detected by IBIS inside the error circle of 3EG J1736 – 2908. On the other hand, while two IBIS sources are found within the 95% error circle of the EGRET unidentified

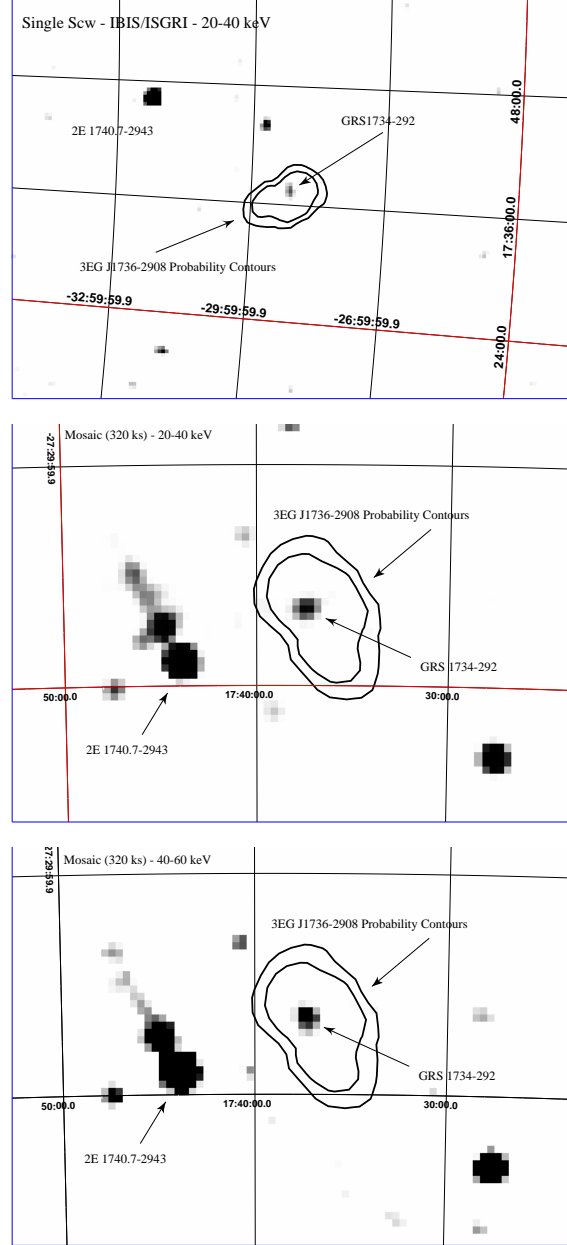


Figure 1. (top panel:) IBIS/ISGRI image of the 3EG J1736 – 2908 region obtained in one ScW (ScW 57 of Rev. 61). (centre panel:) IBIS/ISGRI mosaic (320 ks total exposure time) of the 3EG J1736 – 2908 region in the energy band 20 – 40 keV. (bottom panel) The same as above, but in the energy band 40 – 60 keV. The 95% and 99% EGRET probability contours of 3EG 1736 – 2908 are superimposed. (N.B.: The rotation of the figures in the centre and bottom panels with respect to the single ScW observation of the top panel is caused by the mosaicing procedure.)

source 3EG J1746 – 2851 at the Galactic Centre, no other unidentified EGRET sources match with the INTEGRAL detections. The only other EGRET source coincident with an IBIS source is a known blazar, PKS 1830 – 211 which lies within the error circle of 3EG J1832 – 2110.

¹<http://isdc.unige.ch/index.cgi?Soft+download>

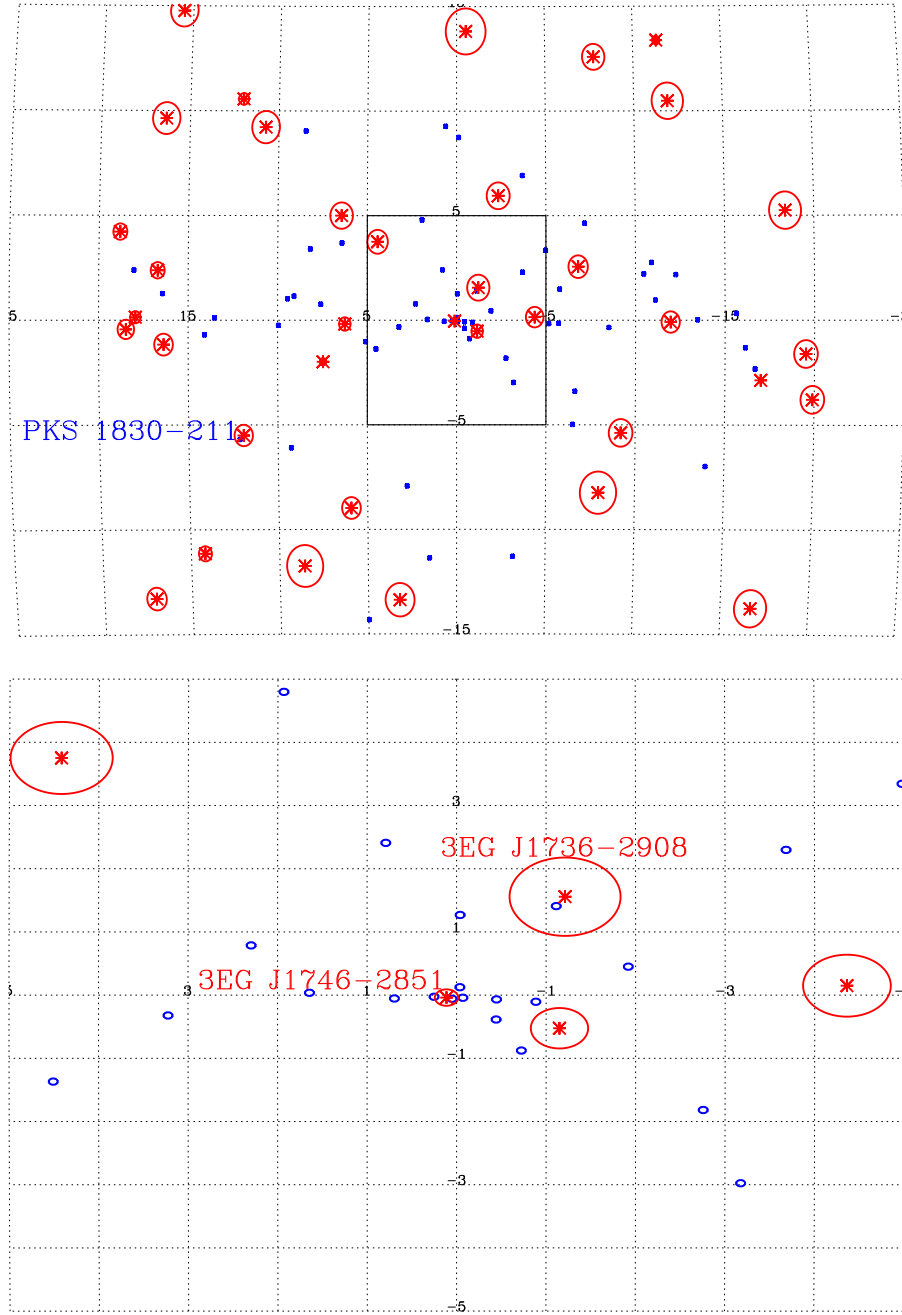


Figure 2. (Top panel:) *IBIS/ISGRI* sources detected by Revnivstev et al. (2004) in the Galactic Centre region survey ($3'$ radius, blue circles) superimposed to the *EGRET* error circles (95% probability radius, red asterisks) in the same region. (Bottom panel:) The zoom panel clearly shows the coincidence position of the source identified as *GRS1734 – 292* with *3EG J1736 – 2908*.

4. CONCLUSIONS

We presented the first results of the early activity in the search for counterparts of the unidentified *EGRET* sources in the framework of the *INTEGRAL* Core Programme. One candidate counterpart has been found close to the Galactic Centre and the identification with the active galaxy *GRS1734 – 292* has been proposed. The cross-correlation of the 2 Ms mosaic of the central radiant (Revnivstev et al. 2004) with the 3rd *EGRET* cat-

alog has not produced other possible counterparts. The research should now be extended to the others regions of the sky covered by the *INTEGRAL* core programme.

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